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7. Abstract

WHC, 1992, *Geology and Aquifer Characteristics of the Grout Treatment Facility*, WHC-SD-EN-TI-071, Rev. 0, prepared by J. W. Lindberg and M. P. Connelly, Westinghouse Hanford Company, Richland, Washington, and J. V. Borghese and B. N. Bjornstad, Pacific Northwest Laboratory, Richland, Washington.

The geology and aquifer characteristics of the area at the Grout Treatment Facility is interpreted and described in support of the Performance Assessment of the Grout Treatment Facility. The study used the most currently available geologic and hydrologic data. A comprehensive set of isopach and structure contour maps is developed for each geologic unit in the area, and geologic cross sections are provided. Groundwater flow, vertical gradients, and hydraulic properties of the uppermost aquifer system are discussed.

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1.0 GEOLOGY OF THE GROUT TREATMENT FACILITY

The geology in the vicinity of the Grout Treatment Facility (GTF) has been discussed in previous reports on the geology and hydrogeology of the 200 East Area for the CERCLA Aggregate Area Management Study (Lindsey et al. 1992; WHC 1992). The following discussion is based on the geologic discussions in those reports but focuses on the GTF. Additional information on Hanford Site geology can be found in Delaney et al. (1991), Myers et al. (1979), and DOE (1988).

This report is based on geologic data derived largely from wells in the vicinity of the GTF. The location of these wells is shown in Figure 1 (the "map area")[1]. The map also shows the boundary locations of the 200 East Area and the GTF, the 216-B-3 Pond System (B-Pond), and the locations of the geologic cross sections A-A' (Figure 2) and B-B' (Figure 3).

Flows of the Columbia River Basalt Group form the bedrock beneath the GTF. These basalt flows are overlain by the Ringold Formation, which is in turn overlain by the Hanford formation (Figure 4). A discontinuous veneer of Holocene eolian sand overlies the Hanford formation.

1.1 BASALT AND INTERBED GEOLOGY AND GEOLOGIC STRUCTURE

The uppermost basalt flows beneath the GTF belong to the Elephant Mountain Member of the Saddle Mountains Basalt which, in turn, is part of the Columbia River Basalt Group (Reidel and Fecht 1981). The Elephant Mountain Member locally contains two basalt flows: the Ward Gap (upper) and Elephant Mountain (lower) flows. The Elephant Mountain flow is continuous throughout the map area. However, the Ward Gap flow, which is present to the southeast, pinches out or terminates to the northwest approximately in the vicinity of the GTF (Graham et al. 1984). The exact position of the termination of the Ward Gap flow is unknown. In the area of the GTF the Elephant Mountain Member is approximately 25 m to 30 m thick.

The Elephant Mountain Member is underlain by the Rattlesnake Ridge interbed of the Ellensburg Formation. Typical sediments in the Rattlesnake Ridge interbed are a lower clay or tuffaceous sandstone, a middle micaceous-arkosic and/or tuffaceous sandstone, and an upper tuffaceous siltstone or sandstone. In the vicinity of the GTF, the Rattlesnake Ridge interbed is about 20 m thick.

The Pomona Member of the Saddle Mountains Basalt lies beneath the Rattlesnake Ridge interbed. In the vicinity of the 200 East Area, the Pomona member is about 50 m to 55 m thick.

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[1]The "map area" is the area in the immediate vicinity of the Grout Treatment Facility. Specifically, it is the area shown in Figure 1 and Figures 5 through 18 (all these maps cover exactly the same area). The "GTF area" (or the area of the GTF) is the area within the boundary of the GTF.

Figure 1. Grout Treatment Facility Location Map.

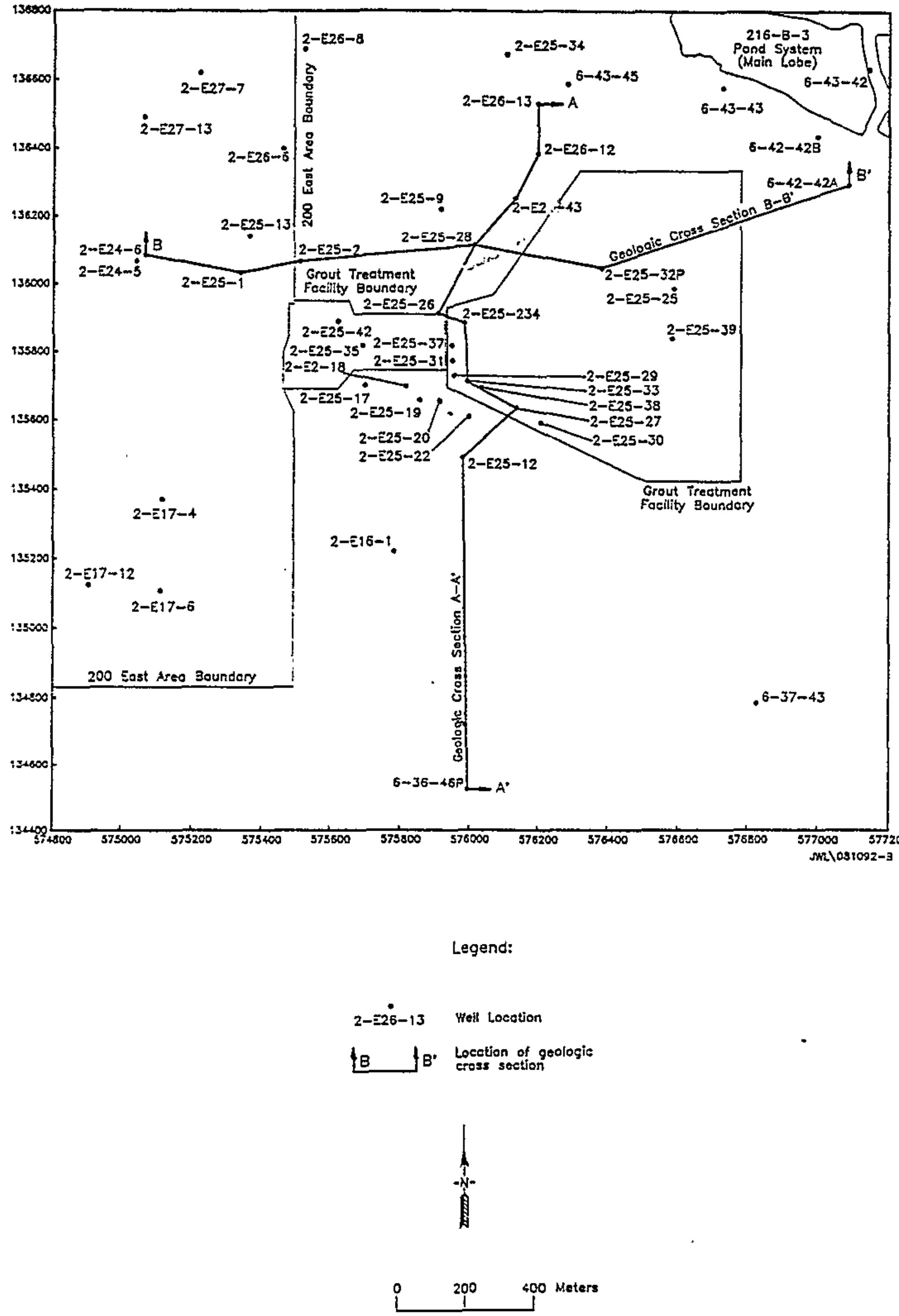


Figure 2. Geologic Cross Section A-A', Grout Treatment Facility.

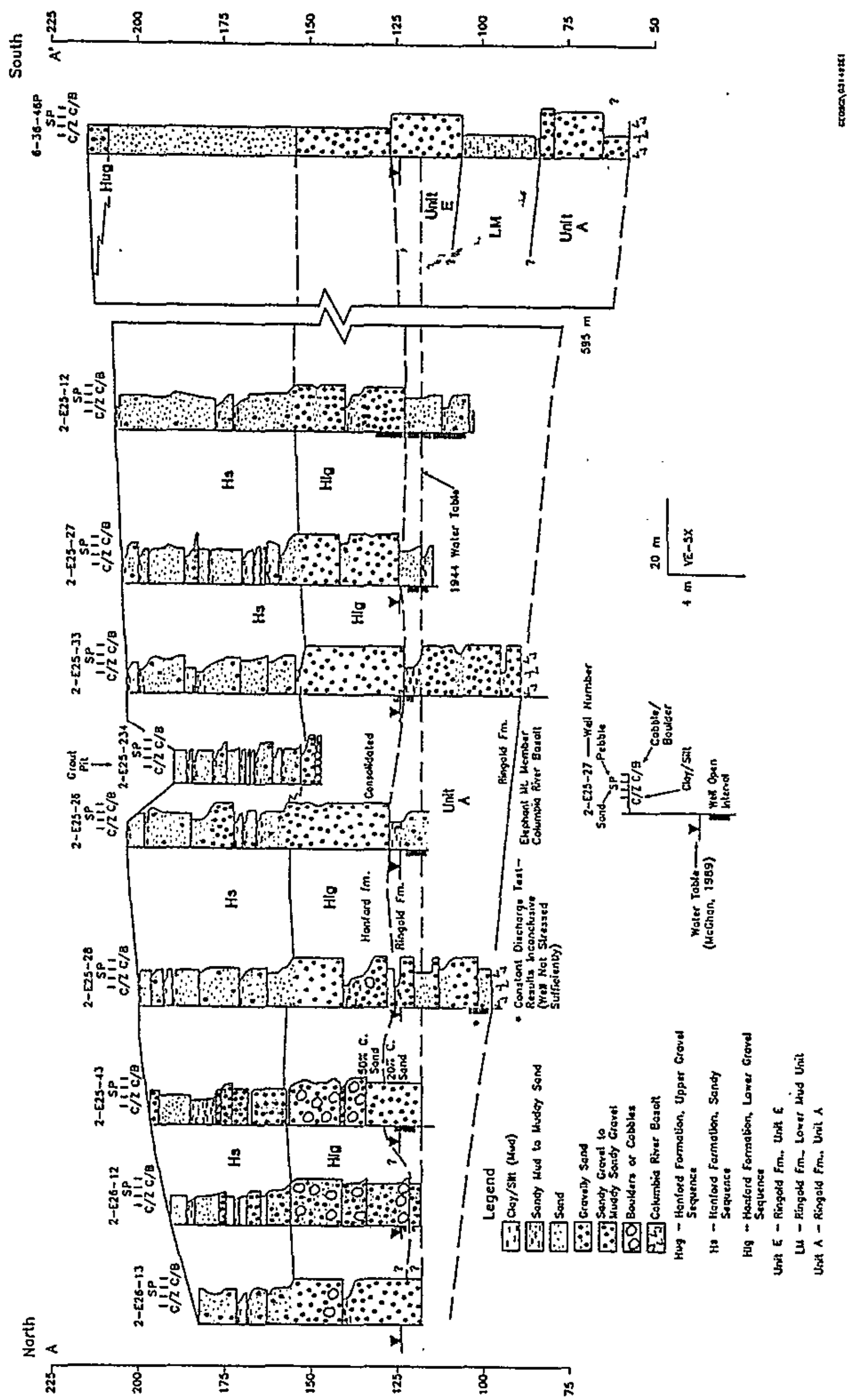


Figure 3. Geologic Cross Section B-B', Grout Treatment Facility.

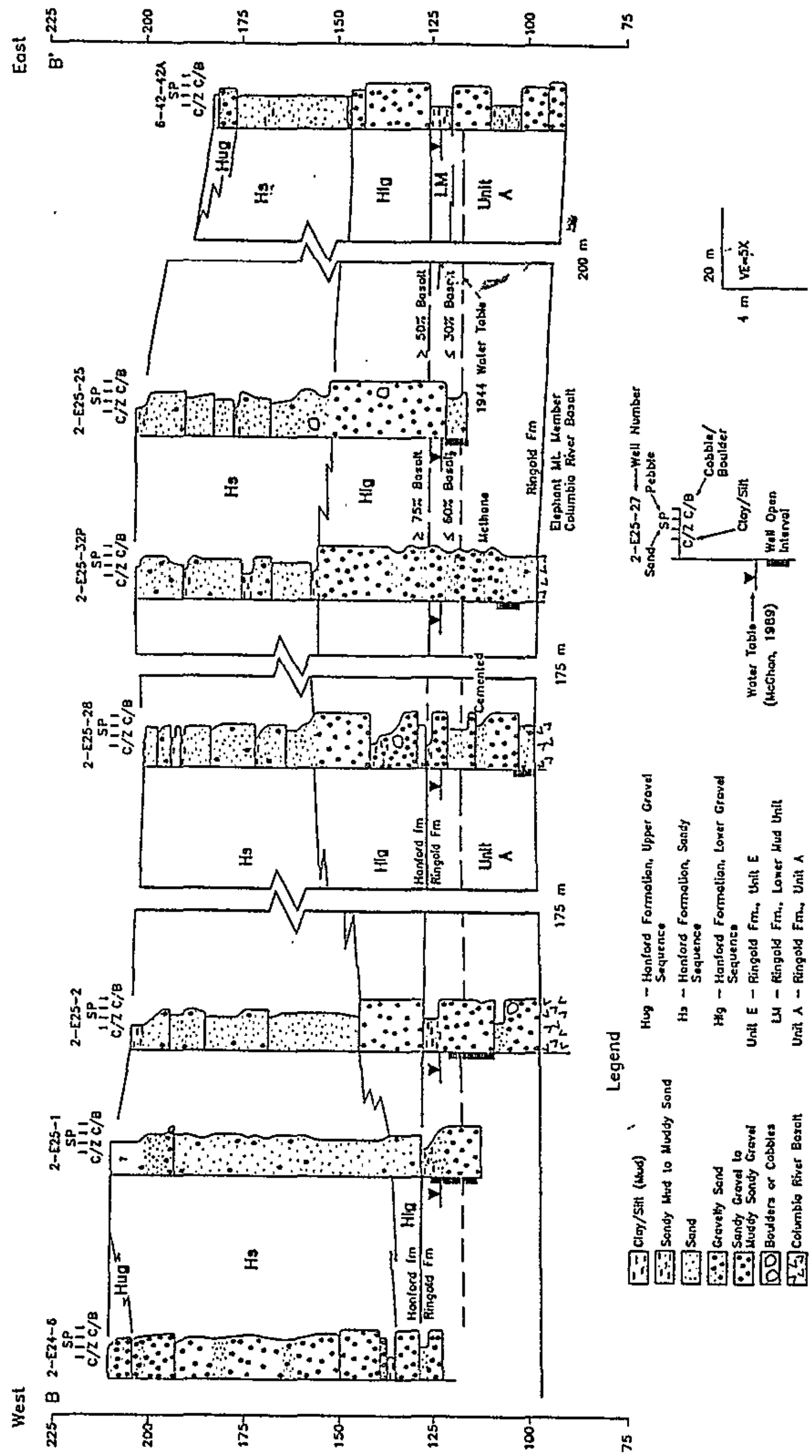
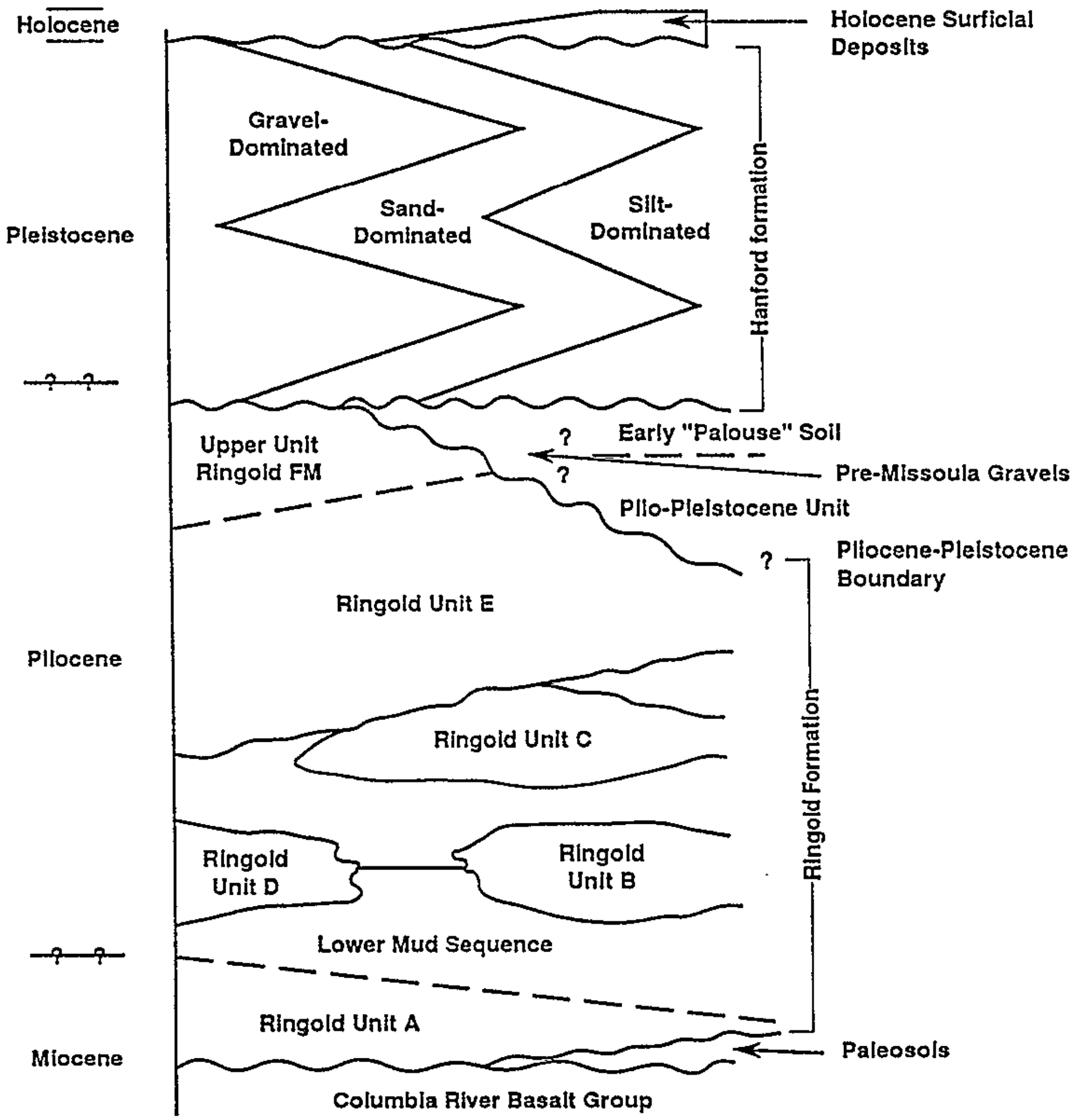


Figure 4. General Stratigraphy of the Hanford Site.



The GTF is situated on the generally south-dipping limb of the Gable Mountain anticline. The Gable Mountain anticline consists of a series of *en echelon*, southeast-northwest-trending folds (Fecht 1978). The main axis lies about 6 km north-northeast of the GTF. Two *en echelon* folds similar to (but smaller than) Gable Mountain occur outside of the map area on the south limb of the anticline between the main axis and the GTF. One of these subsidiary anticlines lies about 3 km north-northwest of the GTF, and another lies approximately 2.4 km to the northwest of the GTF. Both subsidiary anticlines trend northwest-southeast and have been uplifted high enough that basalt is above the current water table.

South of these two subsidiary anticlines, basalt flows, sedimentary interbeds, and Ringold Formation dip southward into the Cold Creek syncline. This southward dip is apparent on a structure contour map[2] of the upper basalt surface (Figure 5). The upper basalt surface dips southward approximately 28 m per km.

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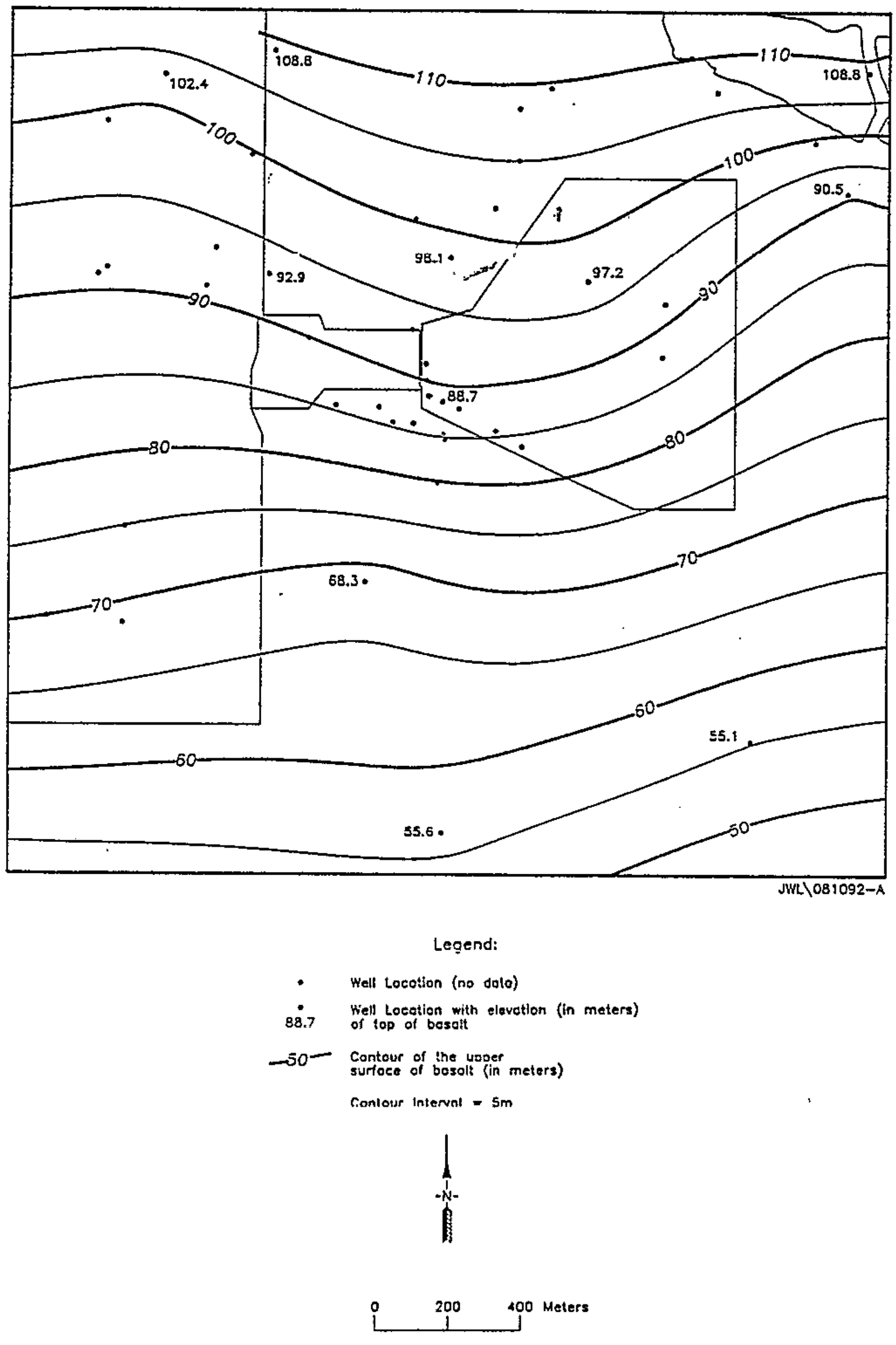
[2]All contour maps in this report were generated by Interactive Surface Modeling (ISM™) from Dynamic Graphics, Inc. on a Silicon Graphics Personal Iris™ engineering workstation. This program uses a bi-harmonic cubic spline to fit a surface through the data points. The isopach maps and structure contour maps were built by generating the top-of-basalt map and then working upward. Each succeeding layer must account for the layers beneath it. Finally, the uppermost layer must be consistent with the ground surface. Therefore, at times the reader will note that there seems to be more detail than the data suggest. This extra detail is from information that was passed from the layers below.

There are both advantages and disadvantages to computerized contouring. The major advantages are ease of contouring, the ability to manipulate the contour maps after generating them, and having a consistent contour method in order to compare changes from map to map. The major disadvantages are poor extrapolation in areas with little or no data, bulls-eyes around inconsistent data points, and extra contour lines with little or no data to explain the contour line. Generally, the advantages outweigh the disadvantages. However, it should be remembered that two-dimensional maps (showing the general trend and values between boreholes) created from one-dimensional borehole data are an approximation at best.

In the contour maps presented in this report, there was an attempt to use all available data. However, only the actual borehole data relating to the particular surface or layer are shown on the maps. For example, if a borehole did not fully penetrate a geologic layer (unit, sequence, formation), an interpolated thickness value was calculated. This thickness value was calculated by subtracting the elevation on the overlying structure contour map from the elevation on the underlying structure contour map. However, at that position on the map a value would not be printed. In contrast, when a borehole fully penetrates a geologic layer, the data derived from that borehole would be printed on the map.

Additionally, control points were used to control the extrapolation in areas where there are few data points. These control points are based on the geologist's knowledge of how these units were trending outside the boundaries used on these maps.

Figure 5. Structure Contour Map Top of Basalt.



9 3 1 2 9 0 4 2 7 7 2

1.2 RINGOLD FORMATION

Ringold Formation strata are found throughout the GTF and vicinity where they overlie basalt. The relationship between the Ringold Formation and the underlying basalt varies between a disconformity and a low-angle unconformity. Strata within the Ringold Formation are divided, from the bottom to the top, into fluvial gravels of unit A, the paleosol and lucustrine muds of the lower mud unit, and the fluvial gravels of unit E (Lindsey et al. 1992). Fluvial units B and D are not present near the GTF, and fluvial unit C and the overbank-dominated deposits of the upper Ringold unit are encountered only at borehole 6-37-43 in the southern portion of the area (Figure 1). Immediately northwest of borehole 6-37-43, fluvial unit C and the upper Ringold unit pinch out. South of borehole 6-37-43, both units thicken into the Cold Creek syncline.

1.2.1 Unit A of the Ringold Formation

The fluvial gravels and intercalated sands of unit A are located throughout the entire map area and generally thicken from less than 10 m near the northern end of the map area to over 40 m near the southern boundary of the GTF (Figure 6). South of the GTF, unit A decreases in thickness to less than 25 m near the southern boundary of the map area. The upper surface of unit A is relatively flat in the northern one-third of the map area, but dips southward in the southern two-thirds (Figure 7). The GTF is located mostly in the northern portion that is relatively flat. This relatively flat area is the portion of unit A locally that was exposed and beveled by Pleistocene cataclysmic flooding. To the south, the unit dips beneath younger Ringold Formation units that protected it from the scouring action of the cataclysmic flooding.

1.2.2 Lower Mud Unit of the Ringold Formation

The overbank and lacustrine deposits of the lower mud unit overlie unit A in the southern and eastern portions of the map area and generally thicken and dip to the south (Figures 8 and 9). The lower mud unit is generally absent within, north of, and west of the GTF. The thickness of the lower mud unit ranges from zero to over 25 m (in the southeastern portion of the map area). None of the wells within the boundary of the GTF encountered the lower mud unit. Therefore, the position of the pinchout of the lower mud unit is unknown. The zero thickness line is irregular and probably runs around the southern portion of the GTF and then northward through B-Pond. The pinchout is due to truncation by overlying deposits of Ringold Formation unit E or Hanford formation.

1.2.3 Unit E of the Ringold Formation

Unit E, the uppermost unit of the Ringold Formation in the vicinity of the GTF, is not found within the boundaries of the GTF. It is composed dominantly of fluvial gravel, but strata typical of the fluvial sand and overbank facies (mud) may be encountered locally. Predicting where intercalated lithologies occur is very difficult. The zero thickness line

Figure 6. Isopach Map Ringold Formation Gravel Unit A.

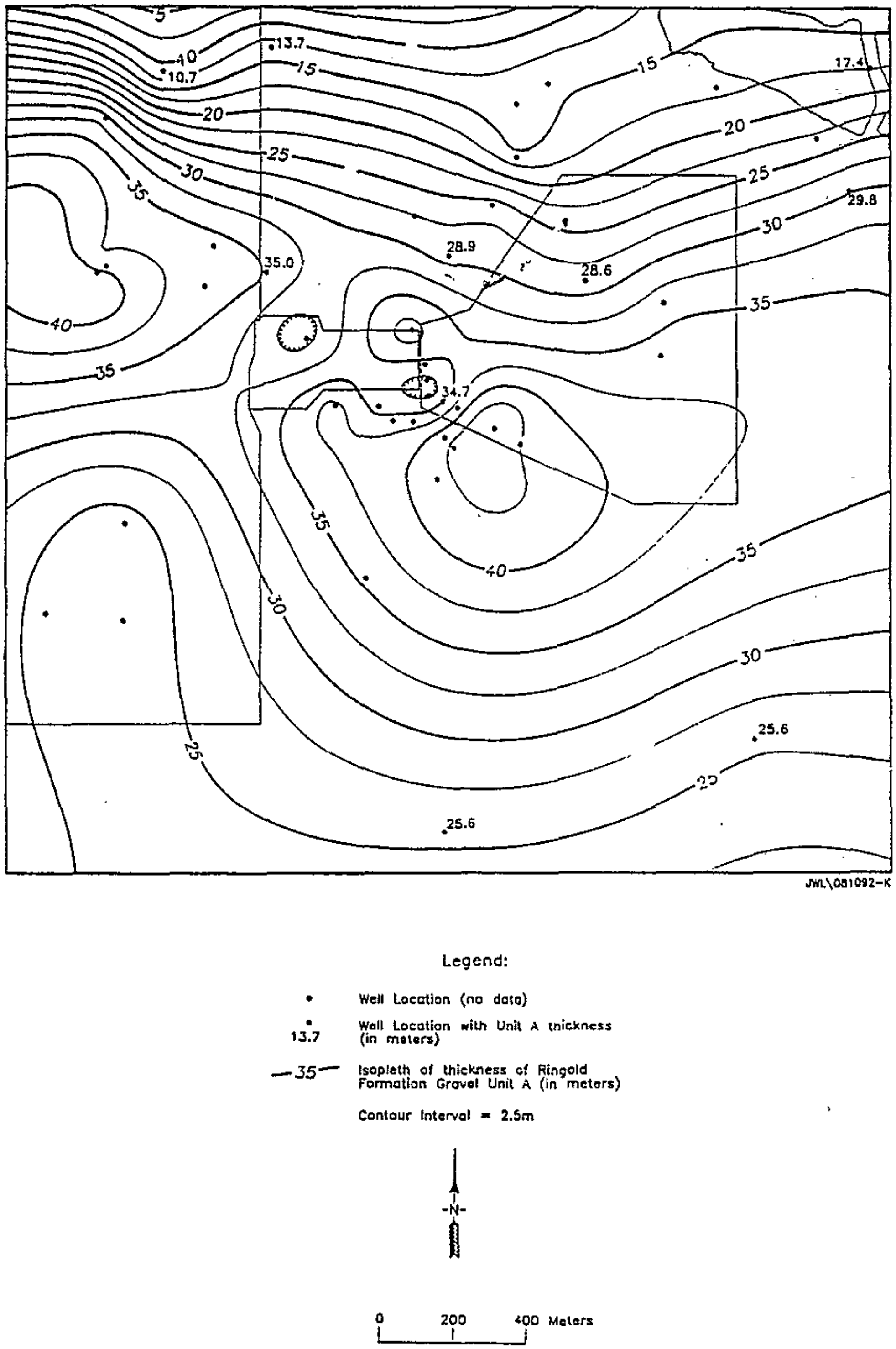
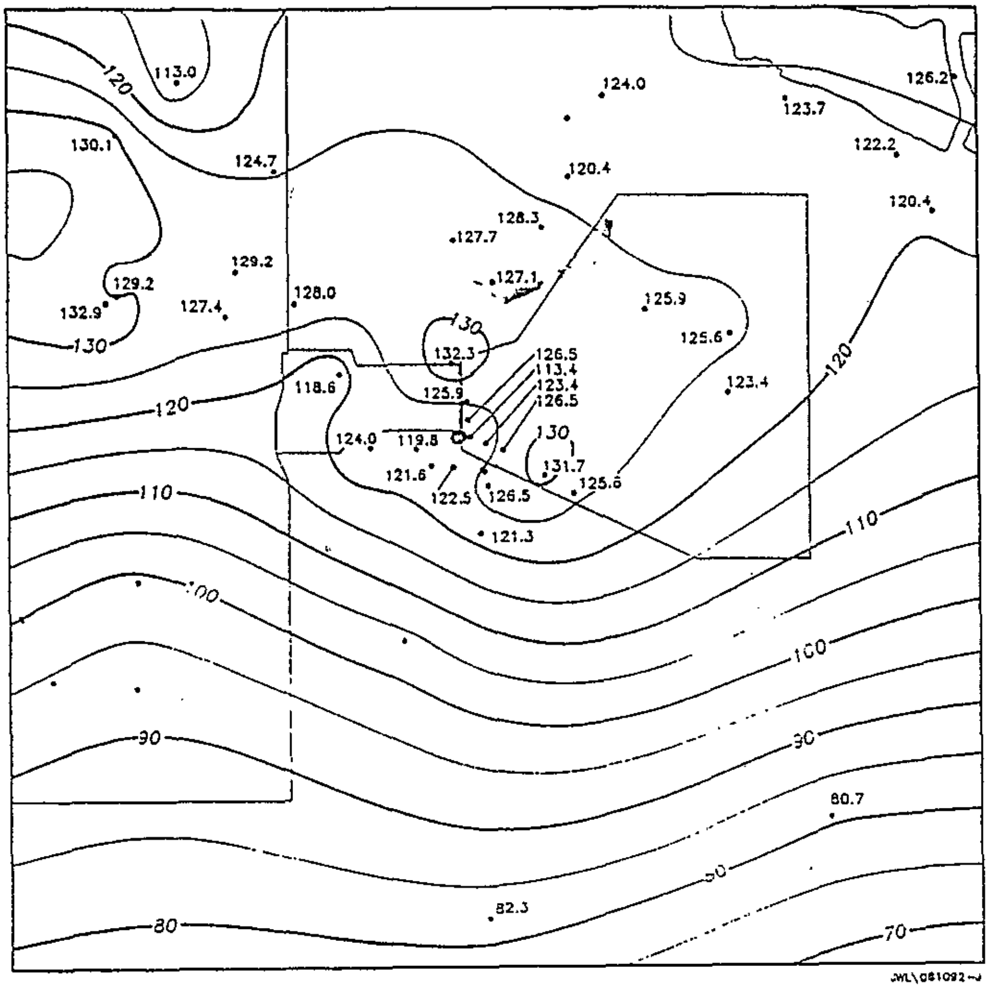


Figure 7. Structure Contour Map Ringold Formation Gravel Unit A.



Legend:

• Well Location (no data)

• 123.4 Well Location with elevation (in meters) of top of Ringold Formation Gravel Unit A

—90— Contour on upper surface of Ringold Formation Gravel Unit A

Contour Interval = 5m

N

0 200 400 Meters

Figure 8. Isopach Map Ringold Formation Lower Mud unit.

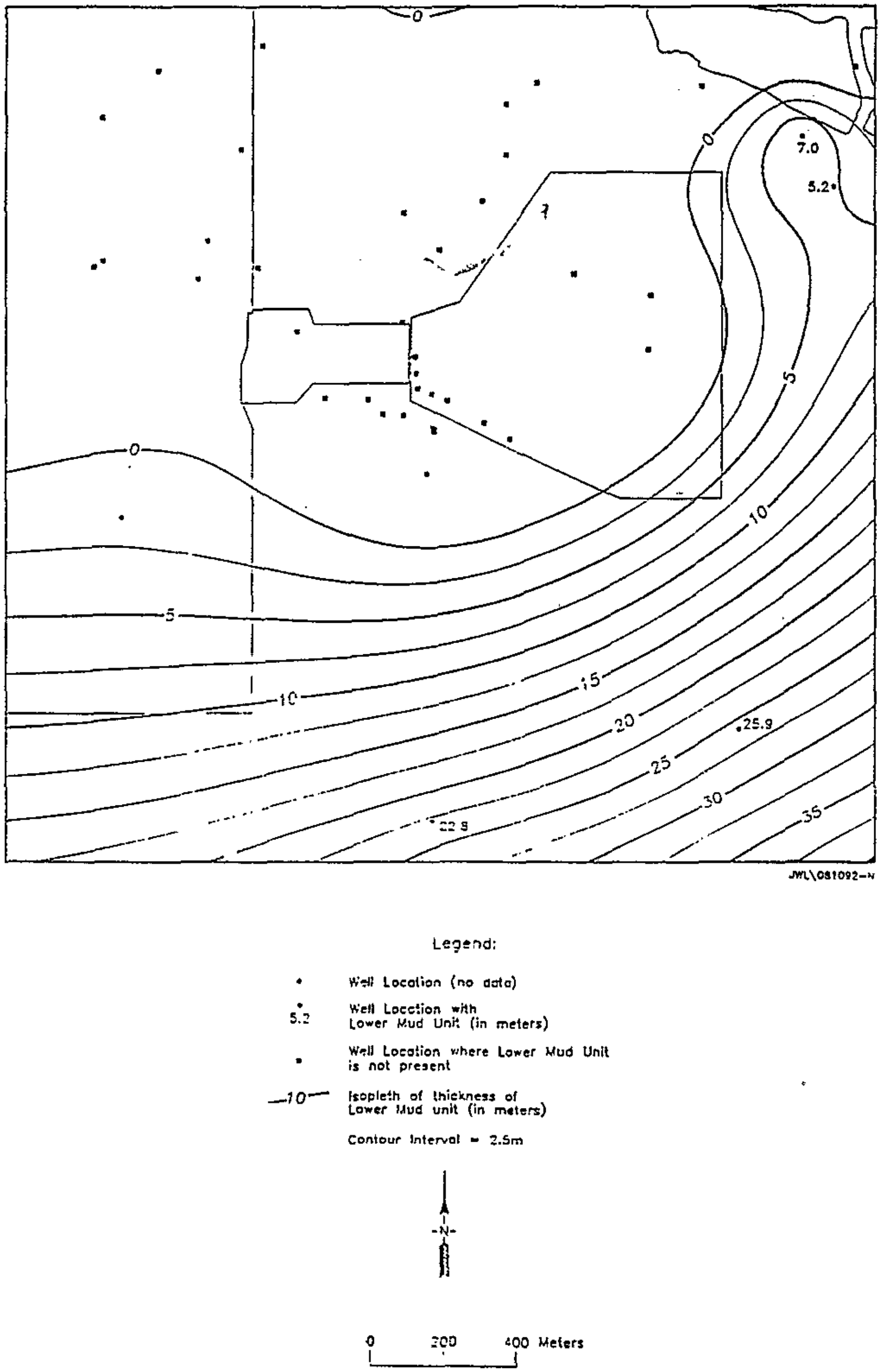
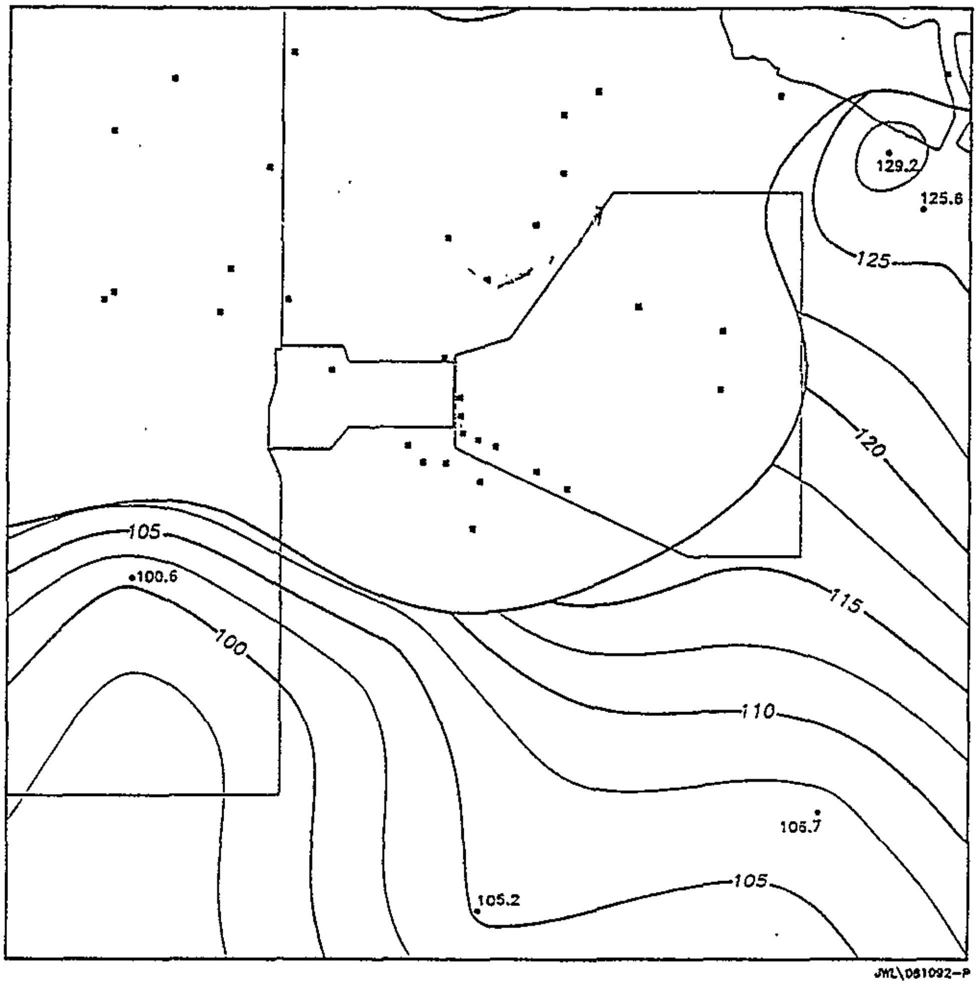


Figure 9. Structure Contour Map Ringold Formation Lower Mud Unit.



Legend:

100.6 Well Location with data

Well Location, Lower Mud Unit not present

—115— Contour on upper surface of Lower Mud Unit (in meters)

Contour Interval = 2.5m

N

0 200 400 Meters

crosses the map area in an approximate east-west direction south of the GTF (Figure 10). The unit generally thickens to the south and somewhat to the west. The unit is thickest in the southwestern portion of the map area (>40 m). The unit generally dips to the north (Figure 11), and its upper surface is very irregular due to scouring by Pleistocene cataclysmic flooding.

1.2.4 Upper Surface of the Ringold Formation

The top of the Ringold Formation consists of Ringold Formation unit A in the northern and central portions of the map area, the Ringold Formation lower mud unit in the east-central portion of the map area, and Ringold Formation unit E in the southern portion of the map area (Figure 12). This surface (which also represents the base of the Hanford formation) is an irregular surface that generally slopes to a local depression in the surface immediately south of the GTF. The surface ranges in elevation from less than 110 m in the local depression to over 130 m to the northwest and southwest (Figure 12).

During and subsequent to the deposition of the Ringold Formation, the uplift of the Gable Mountain anticline tilted Ringold Formation strata in the map area so that the beds dip southward into the Cold Creek syncline (Section 1.1). This uplift positioned the Ringold Formation strata such that subsequent Pleistocene-aged cataclysmic flooding scoured the up-turned ends of the Ringold Formation strata. Cataclysmic flood erosion peeled back the upper layers of the Ringold Formation in the northern portion of the map area exposing the lower mud unit and unit A (Figure 12) and produced the northwest-southeast channel system that is present throughout the map area.

1.3 PLIO-PLEISTOCENE UNIT AND EARLY "PALOUSE" SOIL

The Plio-Pleistocene unit and early "Palouse" soil are not found in or near the GTF. They either never developed in this area or were eroded away during cataclymic flooding. The closest occurrence of these sediments is near the eastern boundary of the 200 West Area (Last et al. 1989; DOE 1988; and Lindsey et al. 1991).

1.4 HANFORD FORMATION

The Hanford formation (informal designation) is continuous over the entire GTF area and vicinity. Figure 12, besides being a geologic map of the top of the Ringold Formation, is a structure contour map of the bottom surface of the Hanford formation. From this map it can be seen that the surface upon which the Hanford formation was deposited is irregular but overall has low relief. This relatively horizontal area is a portion of a large channel sequence that extends southeastward from Gable Gap (northwest of the map area). The channel sequence is identified by eroded and missing Ringold Formation strata and the character of Hanford formation sediments deposited in this area. The channeling and the characteristic Hanford formation sediments are the result of Pleistocene-age cataclysmic flooding that was (in part) directed by the underlying basalt structure (parasitic folds with the same trend).

Figure 10. Isopach Map Ringold Formation Gravel Unit E.

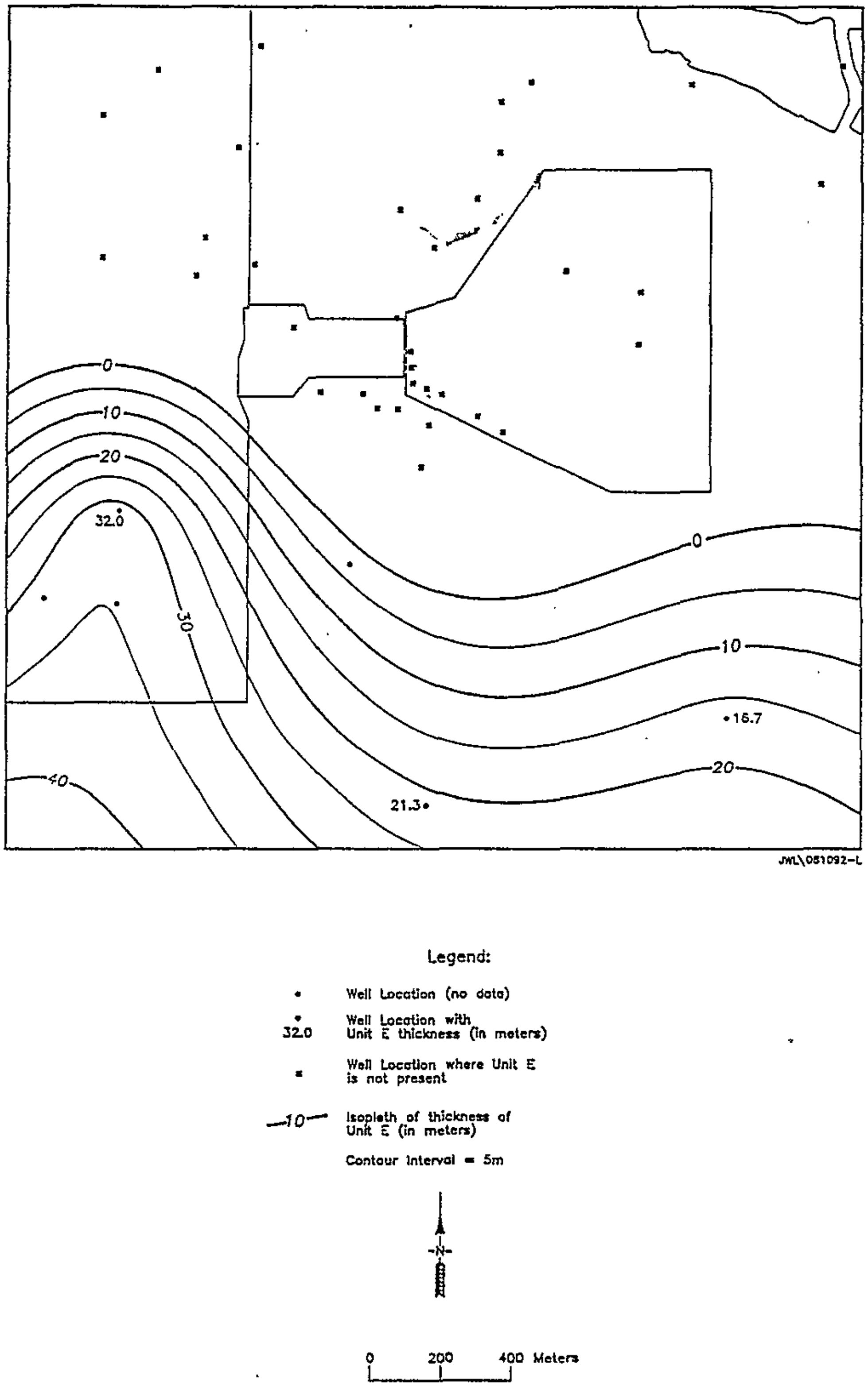


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Figure 11. Structure Contour Map Ringold Formation Unit E.

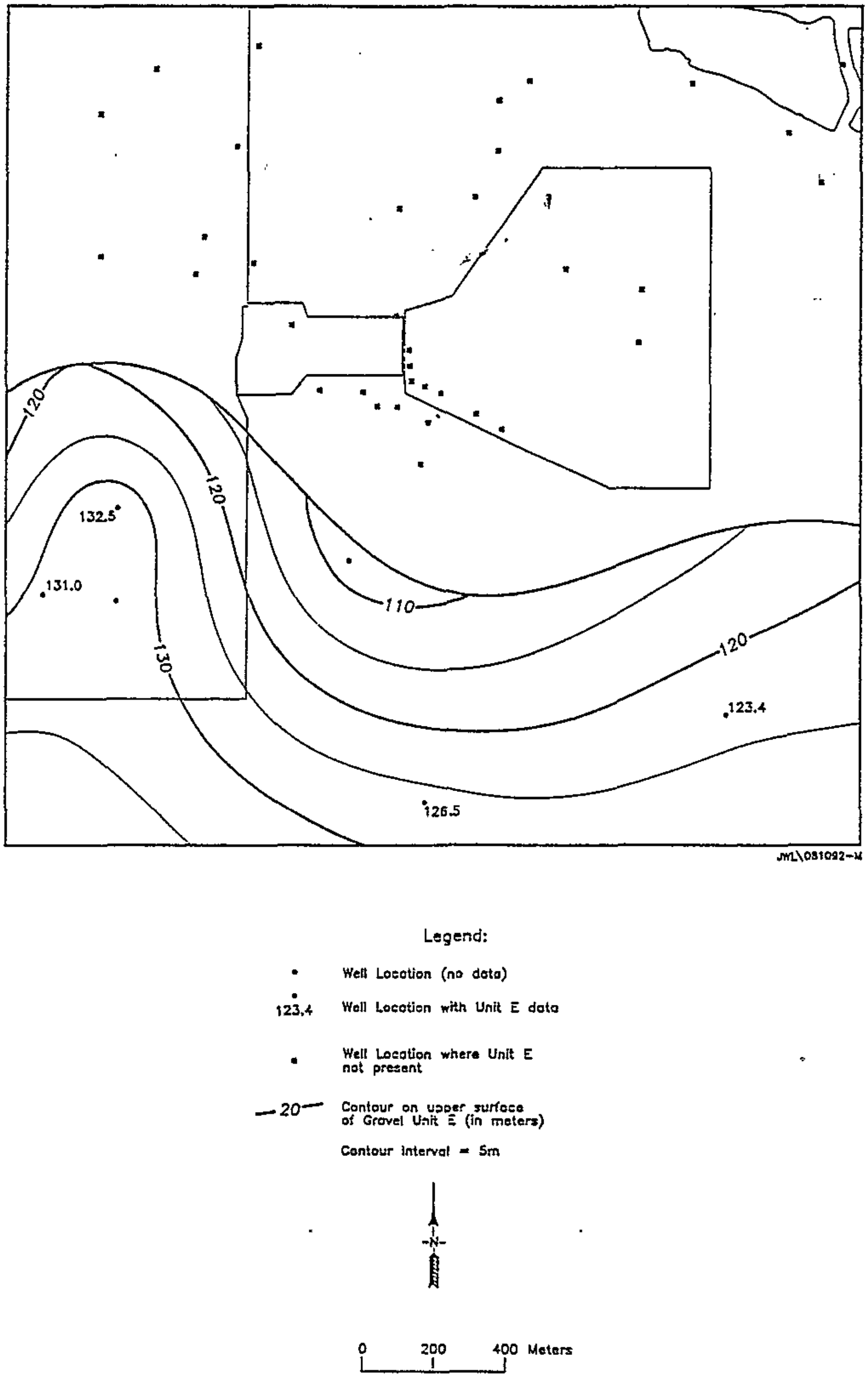
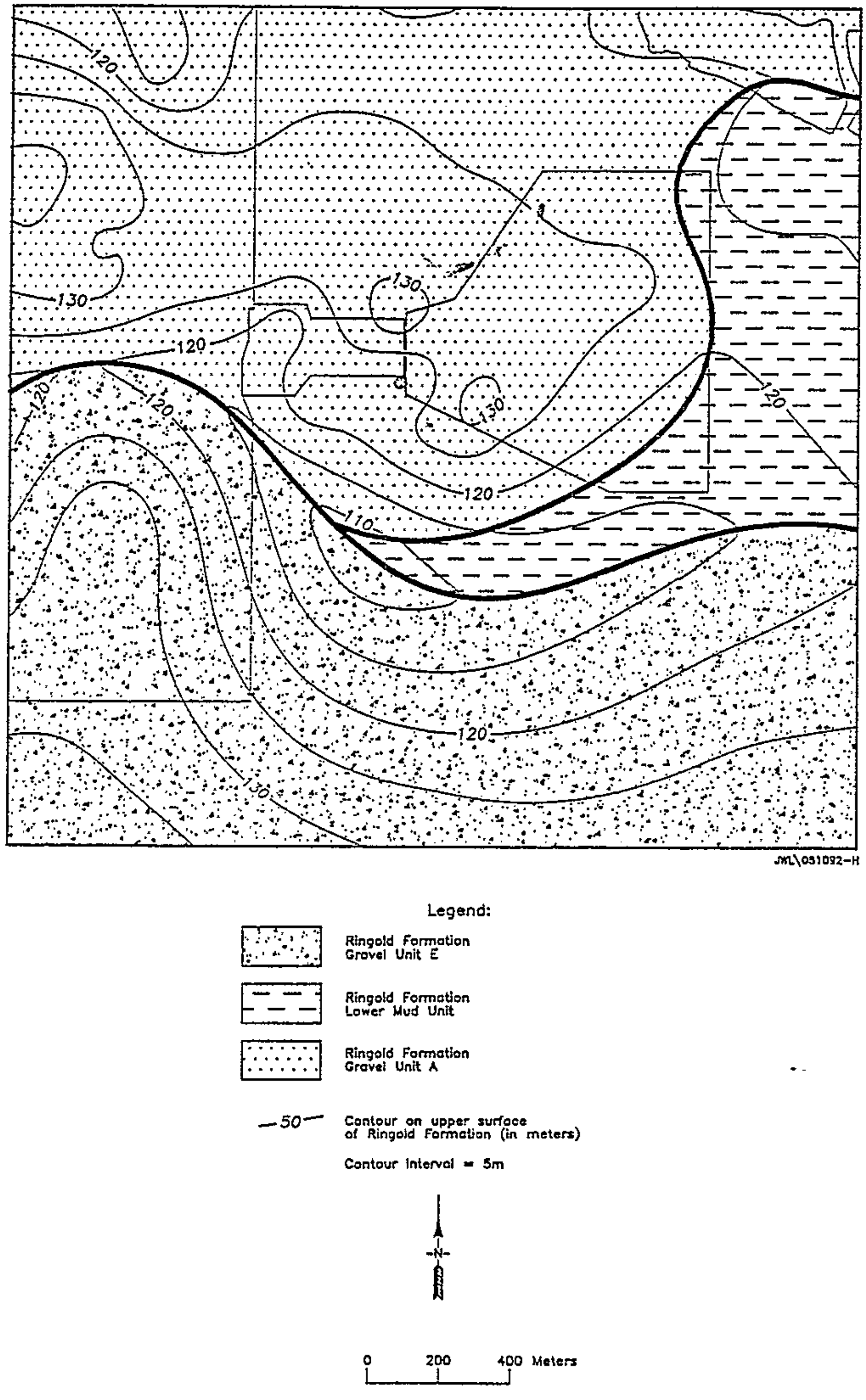


Figure 12. Geologic and Structure Countour Map Top of Ringold Formation.



As discussed in Lindsey et al. (1992), the cataclysmic flood deposits of the Hanford formation are divided into three facies: gravel-dominated, sand-dominated, and silt-dominated. Based on the distribution of these three facies, the Hanford formation is tentatively divided locally into three informal lithostratigraphic sequences. Starting from the bottom, these sequences are designated as follows: (1) lower gravel, (2) sandy, and (3) upper gravel sequences. However, because of the variability of Hanford formation sediments, contacts between these sequences are sometimes difficult to distinguish. Furthermore, these lithostratigraphic sequences are not time-stratigraphic sequences. For example, the lower gravel sequence locally may be time equivalent to the sandy sequence in another location because during one cataclysmic flood event both gravel and sand were deposited at the same time. Gravel was deposited with main channel areas, and sand was deposited toward the margins of channels. The three Hanford formation sequences discussed here are essentially the same strata as identified in Last et al. (1989).

1.4.1 Lower Gravel Sequence

The lower gravel sequence is dominated by deposits typical of the gravel-dominated facies. Local intercalated sandy beds typical of the sand-dominated facies are also found, and some minor beds of silt are found in the southern portion of the map area. The lower gravel sequence is missing in the western and northwestern portions of the map area but thickens to over 40 m in the north-central portion of the map area (Figure 13). In the GTF the thickness ranges from about 10 to 30 m. The upper surface is generally higher in areas where the sequence is thickest and slopes downward toward the pinchout (zero thickness line) to the northwest (Figure 14). The contact between the sandy and lower gravel sequences is placed at the top of the first thick gravelly interval (6 m or greater in thickness) encountered below the sand-dominated strata of the sandy sequence. This contact may not be at the same horizon at all localities because of local facies variability.

1.4.2 Sandy Sequence

The sandy sequence consists of a heterogenous mix of deposits typical of the sand-dominated facies with minor amounts of sediments typical of the silt- and sand-dominated facies. The sandy sequence is differentiated from the overlying upper gravel sequence (where present) on the basis of the relative abundance of sand-dominated versus gravel-dominated deposits. The top of the sandy sequence is placed at the top of the highest thick (>6 m) sand-dominated interval. Although this sequence is composed predominantly of sand, gravel becomes more common toward the north (closer to main flood channels), and silt becomes more common to the south. Thickness of the sandy sequence ranges from less than 30 m northward and eastward of the map area to over 80 m in the western portion of the map area (Figure 15). The upper surface of the sandy sequence generally rises to the southwest (Figure 16), and this rise corresponds roughly with a general thickening of the sequence in the same direction. The sandy sequence may be laterally equivalent with the lower fine sequence in the 200 West Area (Last et al. 1989; Lindsey et al. 1991). The increase in thickness to the southwest also reflects a depositional environment with decreasing flood velocities away from the major flood

Figure 13. Isopach Map Hanford Formation Lower Gravel Sequence.

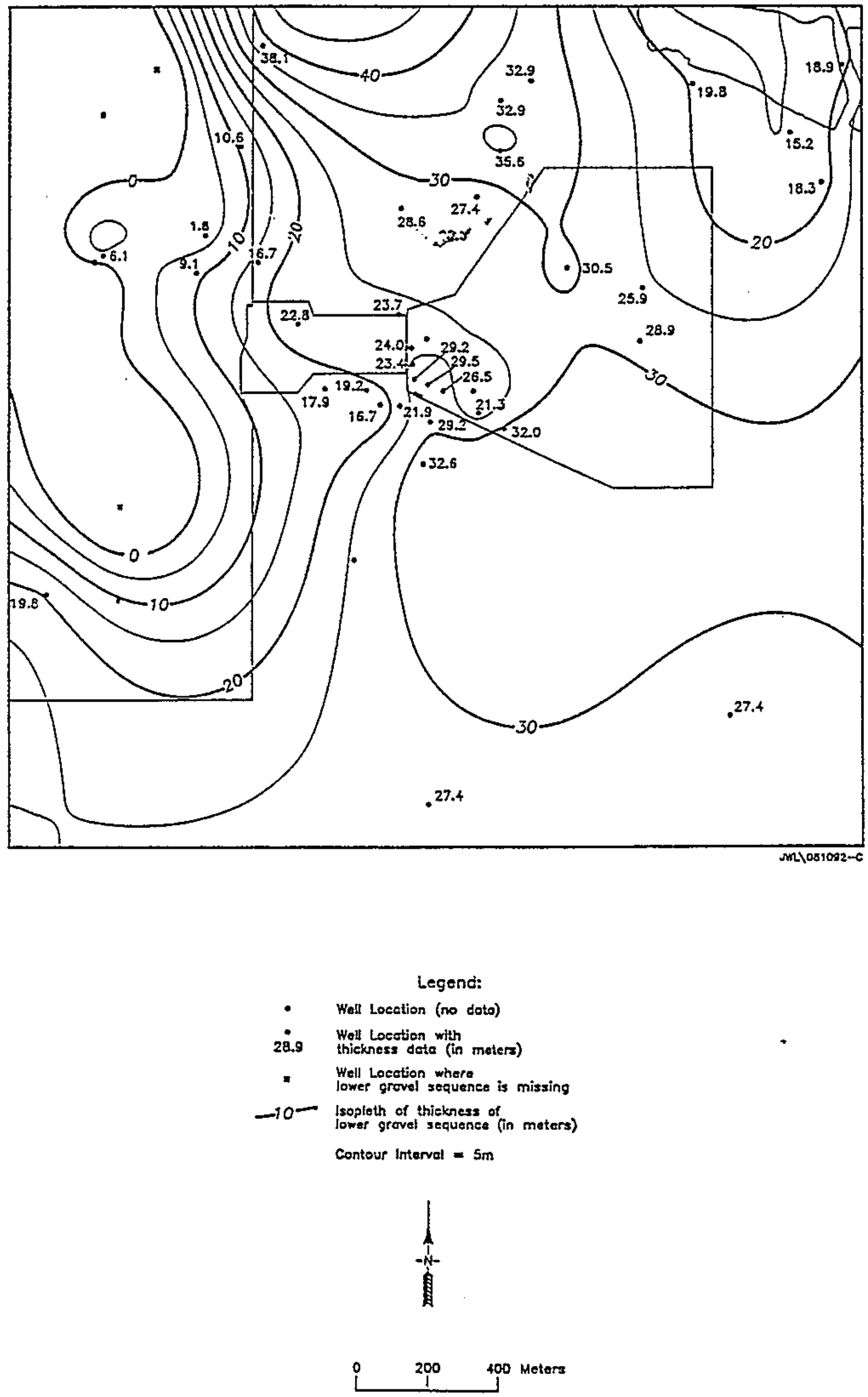


Figure 14. Structure Contour Map Hanford Formation Lower Gravel Sequence.

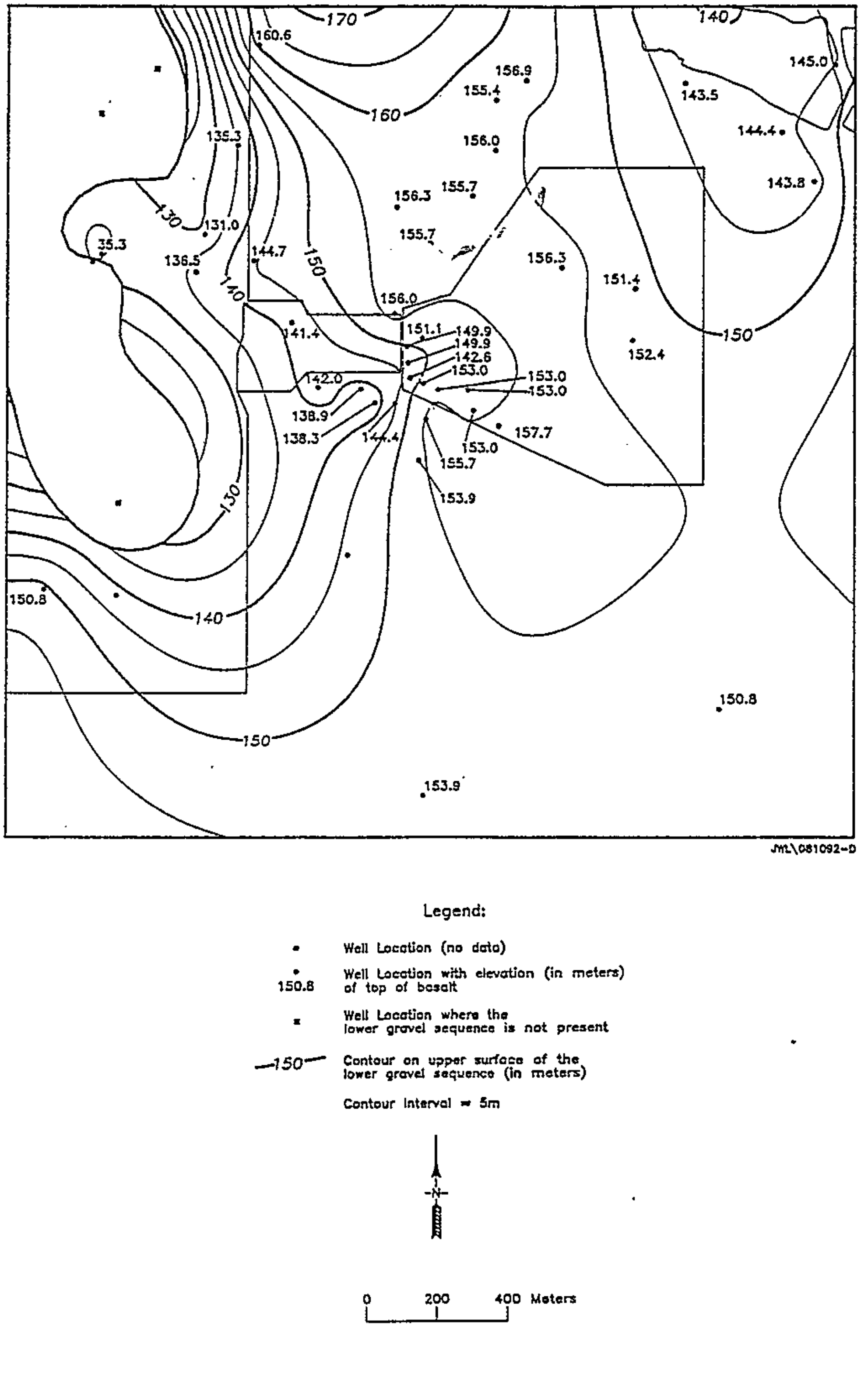


Figure 15. Isopach Map Hanford Formation Sandy Sequence.

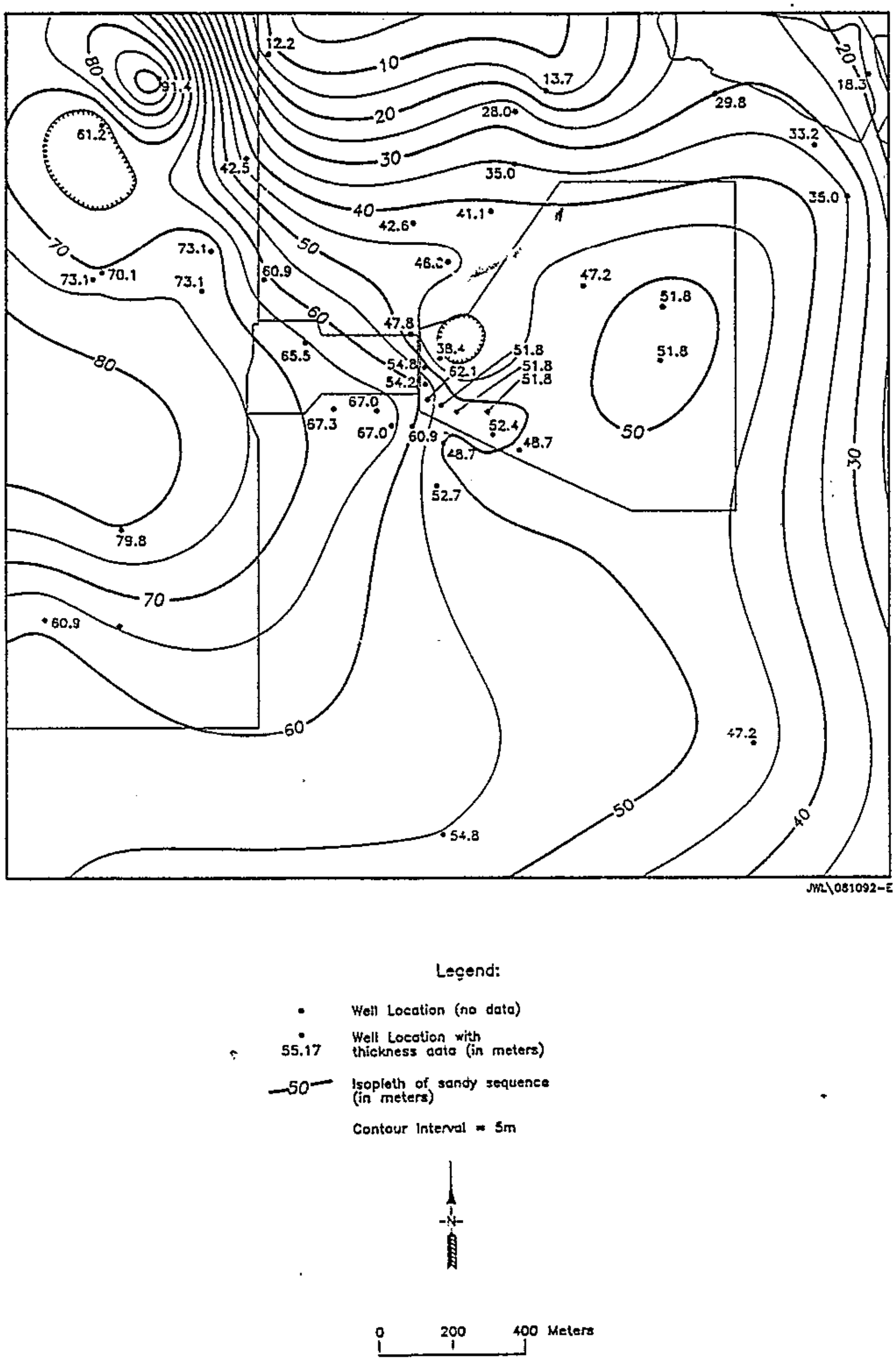


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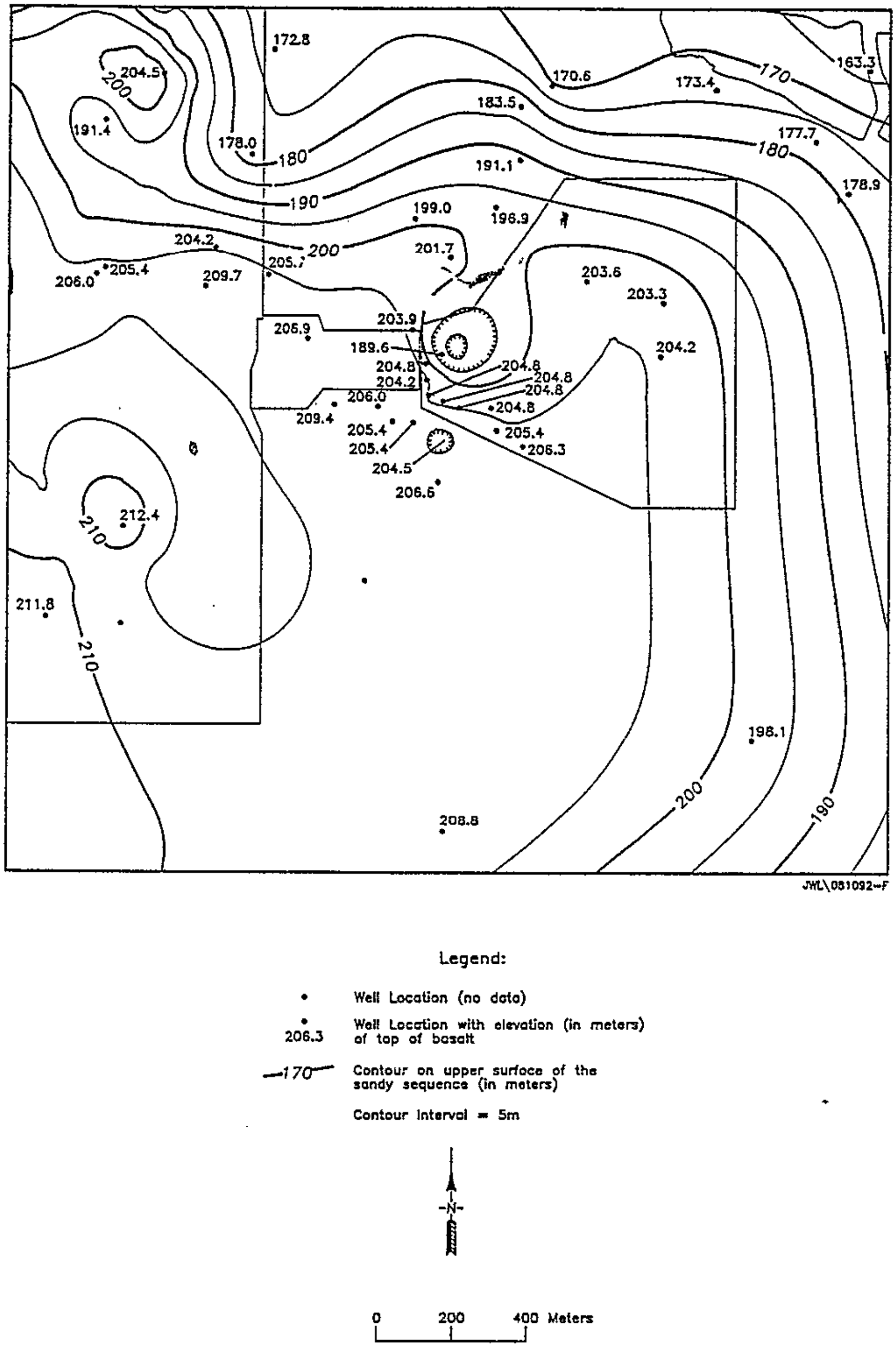
Figure 16. Structure Contour Map Hanford Formation Sandy Sequence.



channels to the northeast. The great thickness of sandy sequence with corresponding rise in the upper contact of the sequence is responsible for most of the flood bar that forms the eastern end of the 200 Areas plateau.

1.4.3 Upper Gravel Sequence

The uppermost deposits of the Hanford formation in the vicinity of the 200 East Area consist of gravel-dominated strata with lesser occurrences of the sand-dominated facies locally. This gravel-dominated sequence, identified as the upper gravel sequence in Lindsey et al. (1992), is missing over much of the area of the GTF (Figure 17). However, it does occur in all areas around the GTF. It is thickest to the northwest and southeast.

1.4.4 Total Hanford Formation

Figure 18 is an isopach map[3] of the total Hanford formation including lower gravel, middle sandy, and upper gravel sequences. The overall thickness of Hanford formation in the GTF ranges from approximately 60 m in the northeast to almost 100 m in the southeast and southwest. However, in the map area, thickness ranges from less than 50 m near B-Pond to over 100 m in the area south of the GTF.

1.4.5 Clastic Dikes

Clastic dikes occur in the Hanford formation in the 200 East Area and vicinity. Several were found in the first excavation of the GTF. They are potentially important because, as discontinuities to the normal sedimentary bedding, they may affect the way groundwater (and contaminants) move in the vadose and saturated zones. Their age is probably Pleistocene, because they do not occur in Holocene eolian deposits and are sometimes truncated by Hanford formation sediments. It is not known whether clastic dikes occur in the Ringold Formation in the map area because they are difficult to identify in drill core, and excavations in the area do not reach the Ringold Formation. They do occur in Ringold Formation sediments elsewhere (Grolier and Bingham 1978), but these occurrences are rare. Total depth of the dikes is also unknown, but they extend over 30 m in the Touchet beds of the Walla Walla River valley (Alwin 1970). Some extend below the bottom of the excavation at the GTF. Where clastic dikes occur elsewhere at the Hanford Site they are often quite abundant and may form polygonal networks where they intersect the ground surface. Newcomb (1962) measured networks of clastic dikes and found they have cell diameters ranging from 15 m to 120 m.

[3]The isopach map of the total thickness of the Hanford formation is a computer generated map that was made by summing the isopach maps of the three sequences within the Hanford formation. The well locations and thickness values at each well location are not printed. Figures A-13, A-15, and A-17 show the contributions of each sequence and the locations of the wells.

Figure 17. Isopach Map Hanford Formation Upper Gravel Sequence.

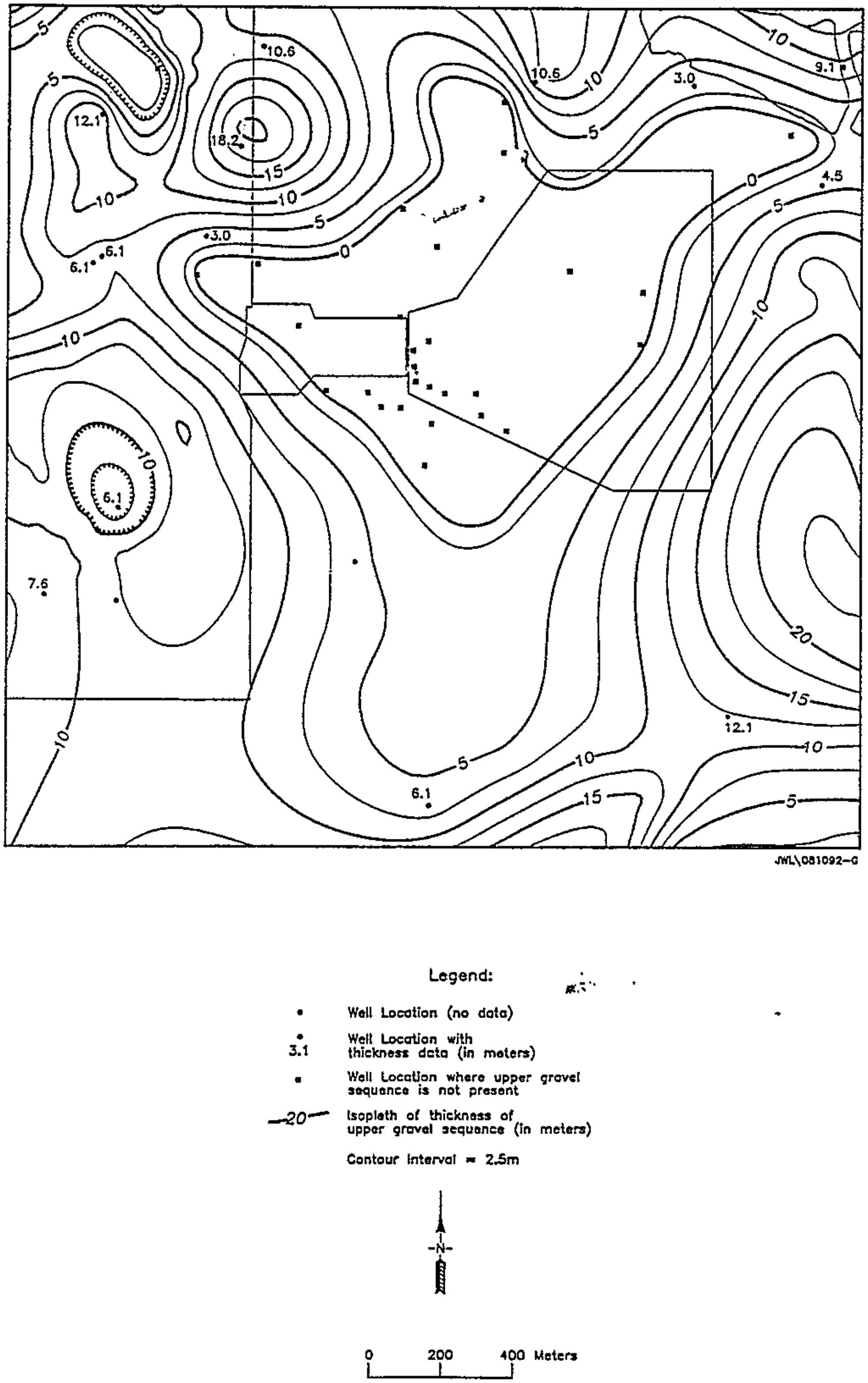
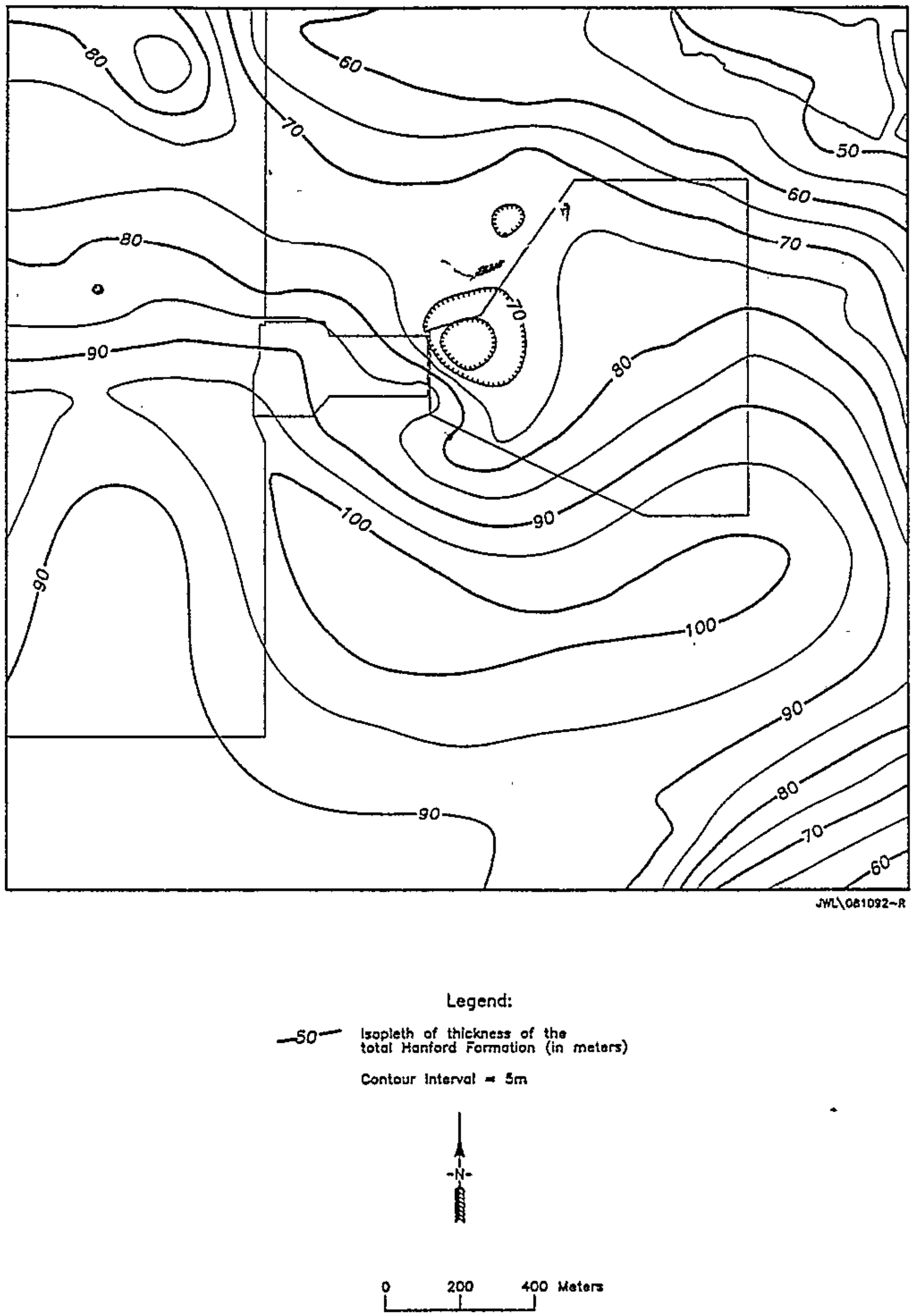


Figure 18. Isopach Map of the Hanford Formation (total thickness).



Clastic dikes are found in all facies of the Hanford formation in the 200 East Area and the GTF, but they are most common in the silt- and sand-dominated facies and rare in gravel-dominated facies. Widths of the clastic dikes range from only a few centimeters to over a meter. Attitudes of the dikes range from vertical to horizontal, with near vertical dikes more common. Material filling the dikes is locally derived and ranges from mud to gravel. Clay, silt, and sand are most common. In some cases, filling material can be traced to underlying, overlying, or interbedded sediments. The dikes are either simple and composed of one layer of filling material, or composite and composed of multiple layers. Sometimes there is a fine layer of clay on dike walls.

Origin of clastic dikes in the Columbia Plateau has been attributed to earthquakes (Jenkins 1925), structural deformation (Flint 1938), melting of buried ice and frozen sediments (Lupher 1944), upward injections of groundwater (Newcomb 1962), thermal contraction of permafrost (Alwin 1970), desiccation cracks or deep frost cracks (Alwin 1970), and extension fracturing from the loading of flood deposits on unstable underlying sediments (Baker 1973). None of these suggested origins can explain all the characteristics displayed by the clastic dikes. They may actually be multigenetic. One mechanism proposed by Black (1979) accommodates most of the characteristics of dikes in the 200 East Area and GTF. He suggests that the dikes were formed during Pleistocene cataclysmic flooding and are the result of hydraulic injection of water and sediment into cracks formed by the sudden loading of water on the ground surface.

1.5 HOLOCENE SURFICIAL DEPOSITS

Holocene-aged deposits in the map area are dominated by eolian sheet sands. These deposits consist of very fine- to medium-grained sand to silty sand. The eolian deposits have been removed from much of the area by construction activities. Where the eolian sands are present they are in thin sheets, usually less than 3 m thick. The Holocene surficial deposits are not differentiated from the upper gravel sequence of the Hanford formation because they are relatively thin and because of the lack of definition on many of the borehole geologic logs available for the 200 East Area and vicinity. The eolian sands are generally stable when covered with natural vegetation. However, when this natural cover is disturbed the silty sand may be blown about by the wind.

2.0 HYDROLOGY OF THE UPPERMOST AQUIFER SYSTEM

The permeable saturated zone within the Hanford Site has been given a variety of names, including the suprabasalt aquifer, unconfined aquifer, semiconfined aquifer, uppermost aquifer, Ringold/Hanford producing layer, and Ringold confined aquifer. None of these names truly fits the aquifer system within the GTF and vicinity (the map area) or the Hanford Site. Delaney et al. (1991), in an attempt to avoid confusion and to standardize Hanford Site hydrogeologic terms, suggested the use of "the uppermost aquifer system" rather than the unconfined aquifer. This report will use the term "uppermost aquifer system" for the suprabasalt saturated zone in the map area.

A conceptual model of the uppermost aquifer system for the 200 East Aggregate Area is presented in WHC (1992). Much of the information presented in this report is gleaned from the WHC 1992 report. The following sections describe the hydrologic characteristics of the uppermost aquifer system within the map area.

2.1 UPPERMOST AQUIFER SYSTEM

The uppermost aquifer system within the map area is defined as the saturated units above the uppermost basalt. The permeable portion of the uppermost aquifer system consists of the lower gravel of the Hanford formation and Ringold units A and E (fluvial gravel units). Where present, the lower mud of the Ringold Formation acts as a confining layer to Ringold unit A. The base of the uppermost aquifer system is the Elephant Mountain Member of the Saddle Mountain Basalt.

The uppermost aquifer system thickens to the south within the map area (Figure 19). The map was constructed by taking the difference in elevation between the water table and the top of basalt. The map indicates that the aquifer is about 20 m thick in the north of the map area and 50 m in the south.

The top of the uppermost aquifer system within the study area is contained within either Ringold unit A, E, the Hanford formation lower gravel sequence (or undifferentiated Hanford formation gravel) or the Hanford sandy sequence. Figure 20 shows the geologic units that the water table intersects. Within the western portion of the GTF the water table is contained within the Ringold unit A. The water table occurs within the Hanford formation lower gravel sequence (or undifferentiated Hanford formation gravel) in the eastern portion of the map area. In the western portion of the map area the water table occurs within the Ringold gravel units A and E and the Hanford sandy sequence.

The upper part of the uppermost aquifer system is under unconfined hydraulic conditions throughout the majority of the map area. However, information obtained from drilling and completion of groundwater monitoring wells near B-pond indicate unconfined conditions are absent in the southeastern part of B-Pond. Graham et al. (1984) noted that the lower mud (Ringold Formation lower mud unit) acts as an aquitard in the southwest portion of the 200 East Area. Davis and Delaney (1992) have stated that in the B-Pond area the lower mud unit also appears to act as a confining unit to the Ringold Unit A. Where the Ringold Formation lower mud unit is present above unit A, as it is within the map area, unit A is considered to be a semi-confined aquifer. Figures 7 and 9 show the extent of unit A and the lower mud unit of the Ringold Formation, respectively. The lower mud unit pinches out to the west of B-Pond and thickens to the southeast (Figure 8; Davis and Delaney 1992).

Figure 19. Isopach Map of the Uppermost Aquifer System.

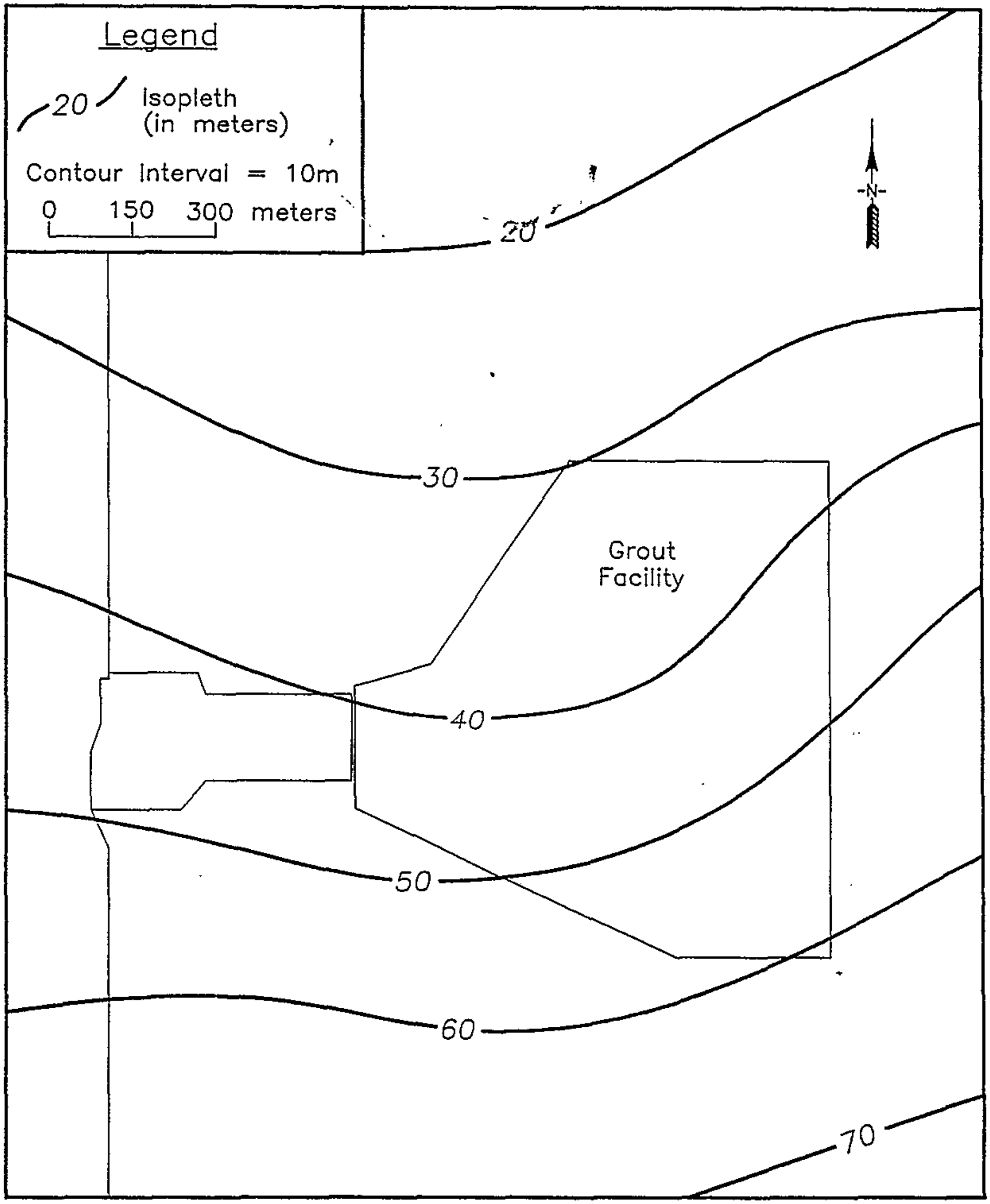


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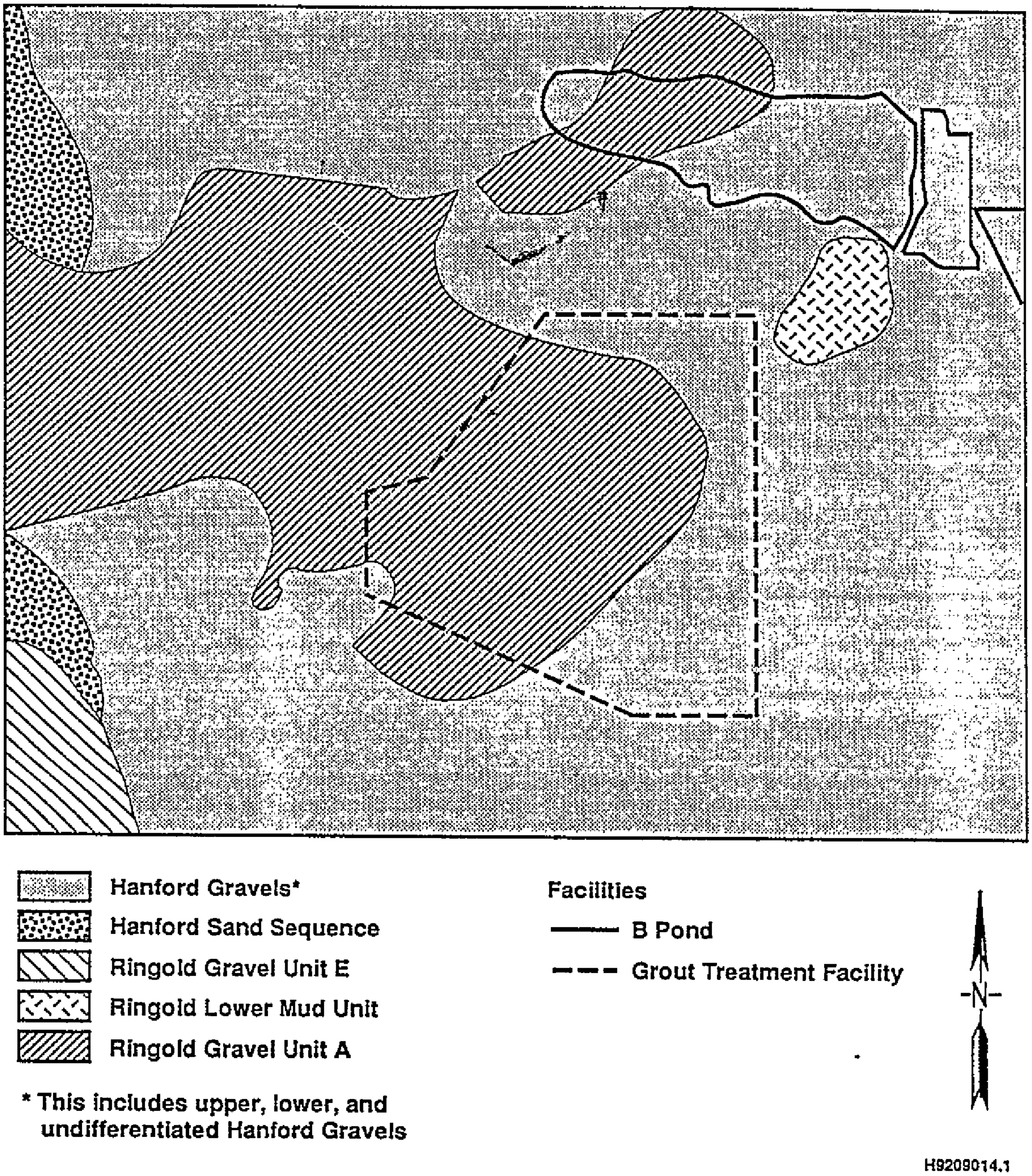
Figure 20. Geologic Map of the Water Table.



2.2 GROUNDWATER FLOW

The direction of the regional groundwater flow for the uppermost aquifer system within the study area is inferred from the Hanford Site Water Table Map and the 200 Areas Water Table Elevation map presented in Kasza et al. (1992). In general, regional flow is from west to east.

The regional flow system has been influenced by artificial recharge within the map area. Newcomer (1990) reports the major influence on the configuration of the water table in the map area is the B-Pond mound. The B-Pond mound has caused a higher water table elevation in the eastern portion of the 200 East Area. The B-Pond mound is declining at present (Newcomer 1990; DOE-RL 1992). Groundwater flow is from west to east in the area between the 200 East and West Areas, radially outward from B-Pond, and generally to the north between Gable Mountain and Gable Butte in the area north of the 200 East Area.

The direction of groundwater flow in the uppermost aquifer system within the map area away from the B-Pond mound historically has been difficult to determine because of the lack of a pronounced horizontal hydraulic gradient. The horizontal gradient has been reported to be very slight (0.0001 to 0.0002) (DOE-RL 1992). The direction of groundwater flow within the map area is inferred from water level data collected from wells in the B-pond area and the map area and by contaminant plumes (DOE-RL 1992). A potentiometric surface map for the upper part of the uppermost aquifer system for B-pond and surrounding area is presented in Figure 21. This map shows a flow direction to the west-southwest through the map area. The tritium plume map given in WHC (1992) shows the plume elongating to the southeast outside the map area. It can be inferred from these data that groundwater flows to the southwest in the eastern and central portion of the map area and to the south or southeast in the western portion of the map area.

2.3 VERTICAL GRADIENTS

Downward vertical gradients in the uppermost aquifer are caused by the B-Pond groundwater mound. Outside of the mound area and within the 200 East Area it is difficult to discern any vertical gradient because of small head differences. Near B-Pond wells 6-43-42J and 6-42-42B monitor the upper and lower parts of the uppermost aquifer, respectively, under unconfined conditions and have an approximate head difference of 0.6 m over a vertical length of about 9 m in a downward direction. The vertical downward hydraulic gradient in this area is about 0.06. Other nested wells, 299-E25-29P and 29Q, and 299-E25-30P and 30Q, 299-E25-32P and 32Q, and 299-E25-34 and 299-E25-28 are located near the Grout Treatment Facility and 216-A-29 Ditch. From the limited data available, the vertical head differences are interpreted to be so slight that they are indistinguishable from measurement error (DOE-RL 1992).

2.4 HYDRAULIC PROPERTIES

Hydraulic properties of transmissivity and/or hydraulic conductivity within the map area were previously determined from the results of aquifer tests, either constant discharge/recovery tests or instantaneous injection/

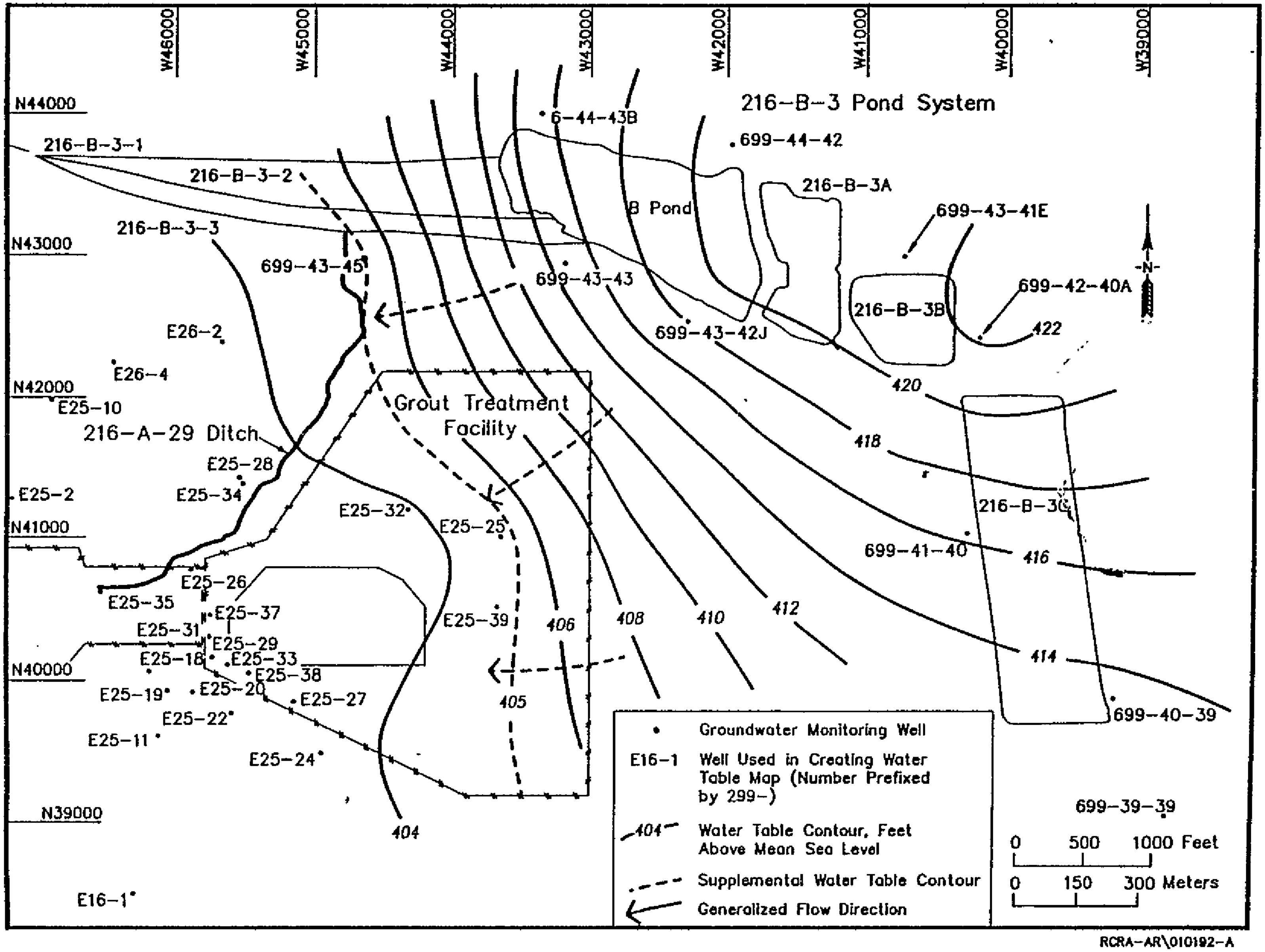


Figure 21. Potentiometric Surface Map for the Upper Part of the Uppermost Aquifer System in the Area of the 216-B-3 Pond System and Grout Treatment Facility (DOE-RL 1992).

withdrawal tests (WHC 1992). The constant discharge/recovery tests were analyzed using the Cooper-Jacob straight line method (Cooper and Jacob 1946). The injection/withdrawal tests were analyzed using either the Cooper method (Cooper et al. 1967) or the Bouwer-Rice method (Bouwer and Rice 1976; Bouwer 1989).

Table 1 lists transmissivity (T) and hydraulic conductivity (K) values from pumping tests of the upper uppermost aquifer system for five wells near or in the map area. Compilation of test data for the 200 East Aggregate Area can be found in Newcomer et al. (1992). Since T was the determined property, the equivalent K is given for comparison with laboratory results. The equivalent K was determined by dividing T by the thickness of the tested interval.

Table 1. Transmissivity and Hydraulic Conductivity Values for the Upper Uppermost Aquifer.

Well number	T ft^2/day	Tested interval thickness (ft)	Approximate equivalent K ft/day[a]	Geologic unit
2-E25-22	100,000 - 200,000	24	6,200 (2)	Ringold unit A
2-E25-32	>100,000	20	>5,000 (1.7)	Ringold unit A
2-E25-33	>100,000	20	>5,000 (1.7)	Ringold unit A
2-E25-34	>250,000	13	>19,000 (>7)	Ringold unit A
2-E25-35	>80,000	12	>6,500 (>2)	Ringold unit A
6-43-43	37,000	18	2,050 (0.7)	Hanford[b] lower gravel
6-44-42	76,000	19	4,000 (1.4)	Hanford[b] lower gravel

[a]Numbers in parentheses are in cm/s.
[b]Hanford lower gravel sequence.
K = Hydraulic Conductivity.
T = Transmissivity.

The majority of the constant discharge/recovery pumping tests were single well tests with partially penetrating well screen. This testing approach does not allow calculation of the storage coefficient. Therefore, there is little information on storage properties for the uppermost aquifer.

The major shortcomings in analyzing injection/withdrawal tests are (1) the limited areal influence of the test, (2) potential sandpack influences, (3) limited stress applied to the aquifer, (4) difficulty in obtaining a complete data set in quick-response formations, and (5) the relatively low values of transmissivity for which the tests are interpretable.

Comparing equivalent hydraulic conductivities that are determined by pumping tests (Table 1) with saturated hydraulic conductivity determined from laboratory tests and reported in Smoot et al. (1989) shows that values from pumping tests are greater by orders of magnitude. This difference may be related to sampling and testing. Laboratory tests are for vertical K and involve small volumes of sediment that are repacked in the laboratory. These small volumes of sediment represent only tiny portions of the drilled intervals. Furthermore, heterogeneities over the recorded intervals cause preferential producing zones which are not detected by laboratory tests. Pumping tests, on the other hand, are for horizontal K and involve large volumes of *in situ* sediments in the vicinity of the wells tested. Another significant factor is the difficulty in analyzing coarse-grained sediments in the laboratory. (Gravel sequences in the Hanford and Ringold formations often contain gravel up to cobbles and boulders in size.) Laboratory tests only involve the finer portion of the samples because the coarse-grained fraction of samples is not collected by the sampling method or is removed prior to testing.

The ratio of horizontal to vertical conductivity at well 6-47-35 (2.3 km east-northeast of the northeast corner of the map area) ranges between 13 and 16 for sediments similar to those in the map area (Graham 1981). However, because of the recognized differences in sampling and testing, it would be inappropriate to try to calculate the ratio for the map area by using values in Table 1 and Smoot et al. (1989).

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